

# **Field Investigations of Lactate-Stimulated Bioreduction of Cr(VI) to Cr(III) at Hanford 100H**

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# **DOE Joint Natural and Accelerated Bioremediation (NABIR) Program and EM Office of Science and Technology Supplemental Call**

**Funding for 2003-2004 - \$ 300,000 per year**

**\$200,000 for LBNL**

**\$90,000 for PNNL**

**\$10,000 for Regenesis**

# Hypothesis

Lactate (HRC) injection into chromium-contaminated groundwater through an injection well will cause bioreduction of chromate [Cr(VI)] and precipitation of insoluble species of [Cr(III)] on soil particles, probably catalyzed at oxide surfaces, at the field scale

# **Objective**

**Perform field investigations to assess the potential for immobilizing and detoxifying chromium contaminated soils and groundwater using bioremediation at Site 100H at Hanford**

# Specific goals

1. Design a field test to measure the effect of lactate biostimulation on microbial community activity, redox gradients, transport limitations, and other reducing agents in comparison with our previous NABIR laboratory work,
2. Establish the rates and conditions that may cause reoxidation of Cr(III) to Cr(VI) following biostimulation,
3. Assess the use of bioremediation in conjunction with alternative remediation technologies.
4. Provide design-criteria for full-scale deployment of in situ Cr(VI) bioreduction via lactate stimulation for use at DOE sites

# **Research Plan**

**Year 1 – Evaluating pre-test (background) conditions, conducting an initial Lactate (HRC) injection test and evaluating its effectiveness**

**Task 1. Test design and field preparation**

- 1.1. Preparations of a detailed plan of field activities – analysis of existing information on a chromium content in soils and groundwater, effect of pumping, plan of drilling activities (PNNL and LBNL)**
- 1.2. Preliminary field investigations using surface GPR acquisition to map the groundwater table and shallow geological contacts, such as the depth to the Ringold formation.**
- 1.3. Borehole drilling and soil sampling.**
- 1.4. Testing field instrumentation.**

**Task 2. Monitoring and analyzing background conditions**

- 2.1. Measurements and sampling groundwater and vadose zone pore-solution and soil gas samples.**
- 2.2. Cross-well geophysical measurements.**
- 2.3. Biogeochemical measurements on core samples**

**Task 3. Development of an initial conceptual model of background conditions**

**3.1 Hydrogeologic and Geochemical Conditions**

**Task 4. Conducting an initial test of Lactate (HRC) injection into groundwater and monitoring flow and transport processes associated with chromium bioreduction**

- 4.1. Equipment mobilization for the test and conducting a preliminary tracer test**
- 4.2. Conducting Lactate (HRC) injection tests**
- 4.3. Sampling groundwater and vadose zone pore-solution and soil gas samples, cross-well geophysical (radar and seismic) measurements, and analysis**

# **Research Plan cont.**

**Year 2 – Conducting a field tests and monitoring to assess a possibility of reoxidation and enhancing the effectiveness of chromium bioreduction**

**Task 5. Continuing field testing of Lactate (HRC) injection to stimulate chromium bioreduction in groundwater**

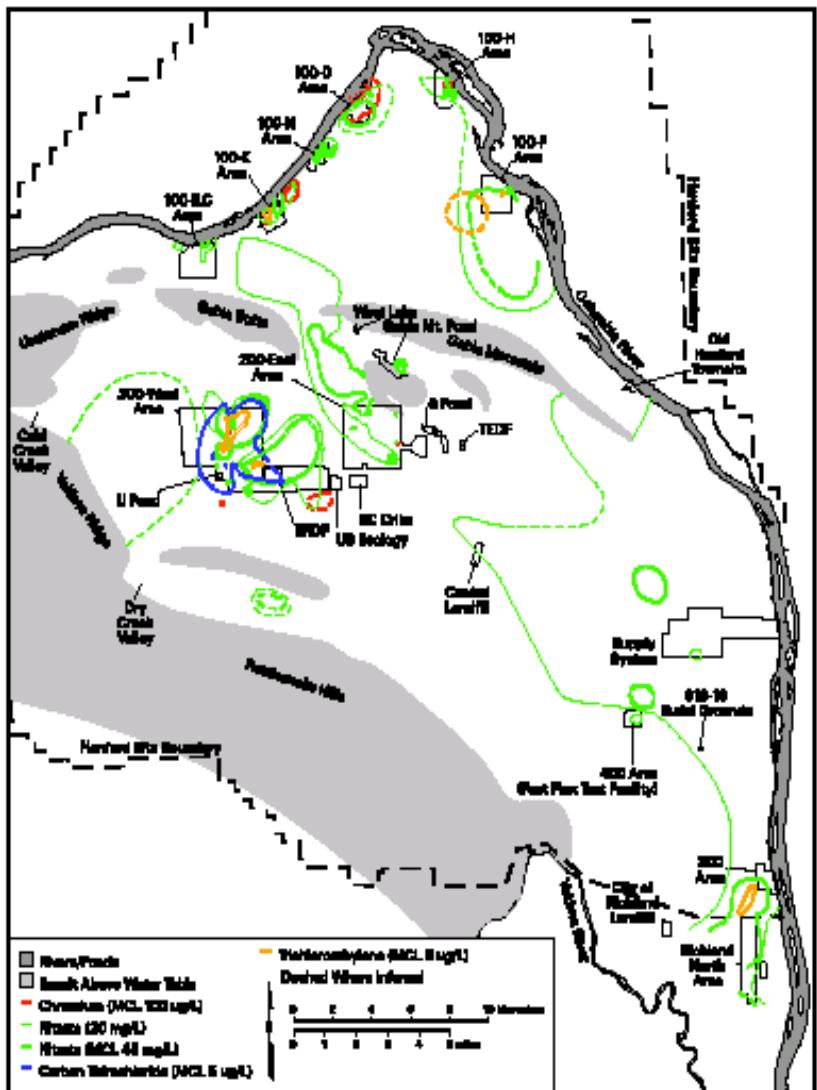
**5.1. Conducting Lactate (HRC) injection tests**

**5.2. Sampling groundwater and vadose zone pore-solution and soil gas samples and analysis**

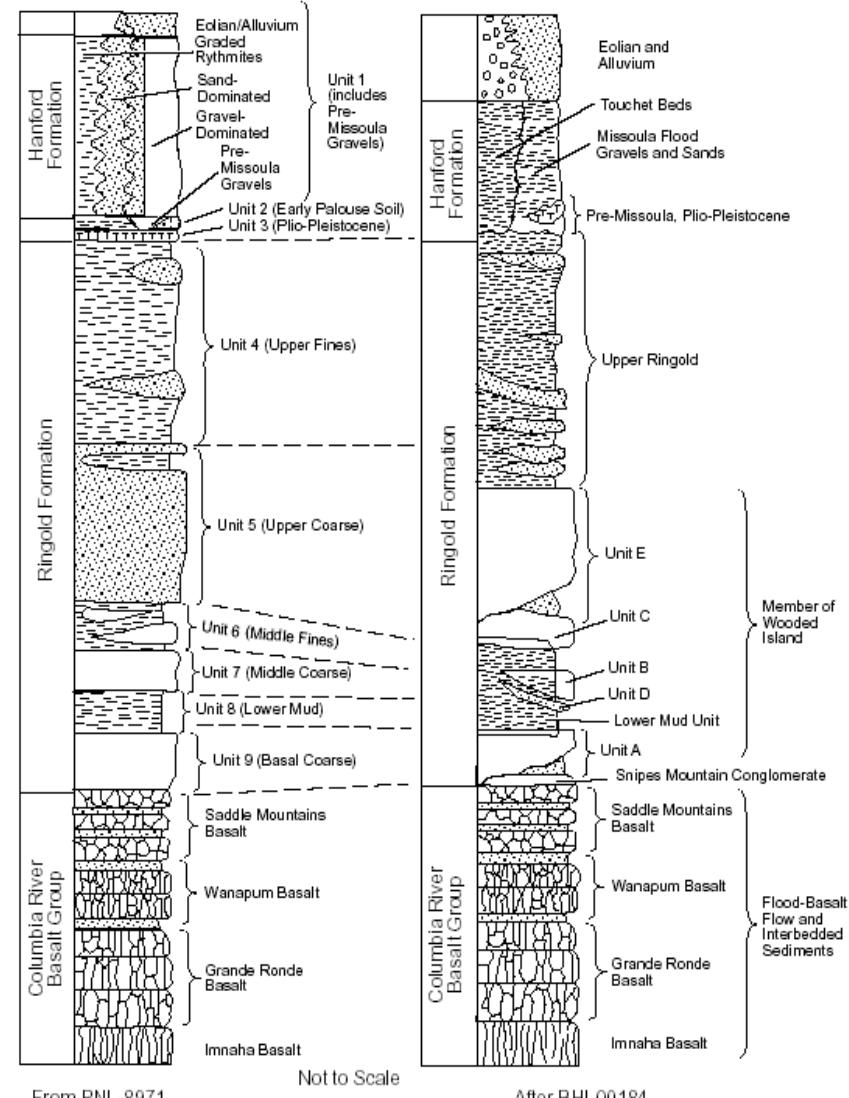
**5.3. Cross-well geophysical measurements**

**Task 6. Post-test monitoring to assess biochemical processes caused by chromium bioreduction and possibility of chromium reoxidation**

**Task 7. Finalize the conceptual model of chromium bioreduction in groundwater on a field scale and recommendations for field deployment**



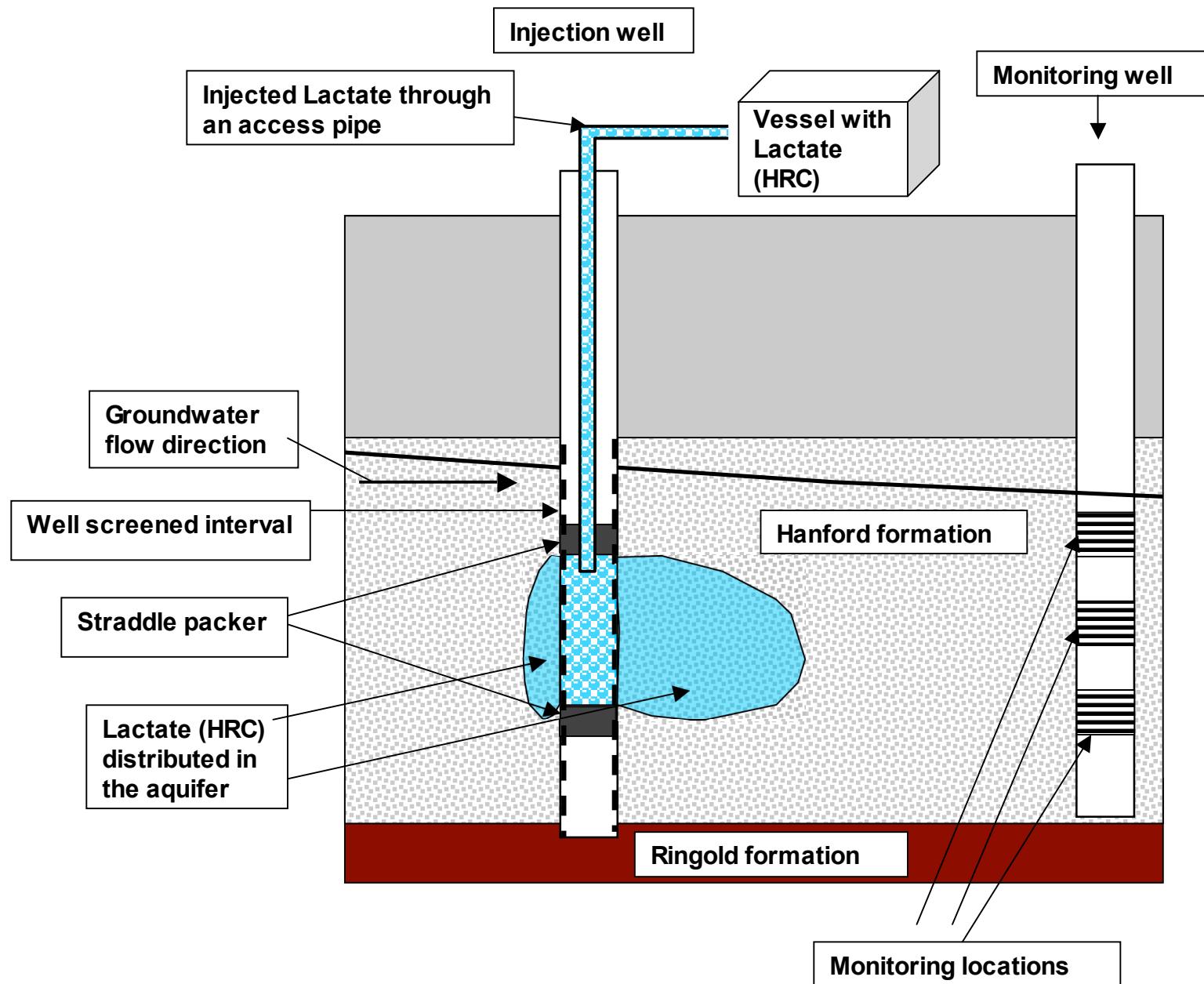
**Distribution of Major Hazardous Chemicals in Groundwater at Concentrations Above Maximum Contaminant Levels, Fiscal Year 1998**



**Relationship between typical vertical lithological and hydrogeological cross-sections of the site.**

RG98120214.14

# Preliminary schematic of the field test design



# Critical and Unresolved Issues for Test Design and Site Selection

- Geologic conditions
  - Lithology
  - Layering
- Hydrogeologic conditions
  - Depth to the water table and seasonal water level fluctuations
  - Directions of flow paths and groundwater velocity between the injection and monitoring wells (tracer test, etc.)
  - Zones of preferential flow
- Depth of drilling to minimize the cost
- Other contaminants and geochemical conditions

## Critical and Unresolved Issues (Cont)

- Zones of influence of the injection and monitoring wells
- Alternative methods for HRC injection
  - Linear source
    - injection through a trench or infiltration gallery
    - injection through a horizontal well
  - Aerial (spatially distributed or discrete intervals) injection
- Consider groundwater pumping through a monitoring well

## Critical and Unresolved Issues (Cont)

- HRC injection
  - Changes the formation permeability
  - HRC solubility and the diffusion coefficient in groundwater from Hanford
  - The zone of influence of HRC in the formation
- A preliminary small-scale injection test

## Critical and Unresolved Issues (Cont)

- Using geophysics to control the zone of HRC distribution in the formation during injection and its degradation over time